attention by Dr. Joshua L. Baily, involves the name Irus Oken, 1815, in Veneracea, the type of which has been accepted as Donax irus Linnaeus, 1758, by tautonymy. This generic name could have been credited to Gray, 1847, with that species as type, but unfortunately Oken himself used it in 1821 in his "Naturgeschichte für Schulen", p. 647, with two species, neither of which is veneracean; one is the type species of Pandora Chemnitz, 1795 (Tellina inaequivalvis) Gmelin (= Solen inaequivalvis Linnaeus, 1758), the other Mytilus rugosus, a doubtful species of Hiatella, probably a variant of H. arctica (Linnaeus, 1758). The former, "Tellina inaequivalvis", is here designated as type of Irus Oken, 1821, which becomes a synonym of Pandora, reverting to the usage of Blainville, Deshayes, and other nineteenth-century writers. This leaves the veneracean group without a name unless, (a) one petitions the International Commission for protection of Irus Oken, 1815 — a procedure that on the average requires approximately five years — or, (b) elevates one of the named subgenera of the group to generic rank (these would take precedence over any new name that might be proposed). Three such names are available: Notopaphia Oliver, 1923, the type species from New Zealand, Venerupis elegans Deshayes, 1854; Notirus Finlay, 1928, type species, Venerupis reflexa Gray, 1843, also from New Zealand; and Paphonotia Hertlein and Strong, 1948, type species, Petricola elliptica Sowerby, 1834, from Tropical West America. The type of Notopaphia is elongate, with fine concentric ribs and a sinuous ventral margin. Perhaps this group might well be elevated to generic rank. Notirus would then be available as the generic name for the Irus group. Notirus, s. s., would include those ovate-quadrate forms with fine to coarse concentric ribs, and Paphonotia would include those with stronger radial sculpture. The genus ranges in time from Oligocene to Recent in Europe but in the Recent is mainly distributed in the Pacific, with only one species, Donax irus Linnaeus, in the Mediterranean. The Californian species presently known as Irus lamellifer (Conrad, 1837) probably should be considered to fall in Notirus, s. s., at least until such time as someone makes a thorough review of all known species in the group.

The generic name Clathrus Oken, 1815, in Epitoniidae, with Turbo clathrus [Linnaeus, 1758] as type by tautonymy, was (according to Dr. Robert Robertson, in litt.) validated by Oken in 1821.

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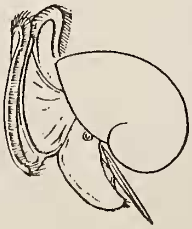

A New Method of Determining the Accuracy of Geotactic Orientation of the Snail *Helix aspersa* Müller

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(3 Textfigures)

Helix aspersa Müller progresses upward when placed upon inclined surfaces. Thus, this animal strongly demonstrates negative geotactic orientation. Some of the work dealing with geotactic orientation has recently been reviewed by Carthy (1958). The accuracy of orientation was determined by the magnitude of the probable error of each animal's angle of orientation (Crozier and Pincus, 1927) but not directly by mathematical equations. Geotactic orientation of H. aspersa was found by Cole (1927) to be controlled by the equality of tensions produced within the proprioceptors in the body musculature by gravity. The accuracy of geotactic orientation of H. nemoralis has been found by Hoagland and Crozier (1929) to decline in proportion to an increase of the angle at which the surface is inclined from the horizontal. They also found that when this snail progressed on either a vertical or a horizontal surface, the longitudinal axis of the snail's body was parallel to the longitudinal axis of the shell, but when this alignment was changed by inclining the surface, the snail turned until the two axes were again parallel.

Equations have been used to describe directly the orientation paths of rats (Crozier and Pincus, 1926, 1927), mice (Crozier and Oxnard, 1927), slugs (Wolf, 1927), and snails (Hoagland and Crozier, 1929). The determination of an animal's accuracy of geotactic orientation directly by mathematical equations shows that this type of behavior is orderly and can be quantified. This is essential if behavior patterns are to be compared and if behavior patterns are to have taxonomic value.

The purpose of this study is to develop a series of mathematical equations that can be used to describe quantitatively the accuracy of geotactic orientation of an animal, and to determine the geotactic orientational accuracy of Helix aspersa by these equations. The first equation will describe the animal's true orientation path in terms of the angle between the animal and the horizontal, and the second equation will determine the animal's accuracy of orientation in terms of the difference in degrees between the animal's true orientation path, or true bearing, and the angle of inclination of the surface.

Materials & Methods

Specimens of Helix aspersa were collected in Richmond, Contra Costa County, California, from 24 September, 1960, to 29 May, 1961. The animals were maintained on oatmeal, calcium carbonate, and lettuce. Before being used for experimental purposes, each snail was confined for a period of between two and three days in a quart jar with a substrate of half an inch of small rock covered with one and one-half inches of moist soil.

An apparatus was developed to determine the angular deviations of the snail's path from the vertical on the surface (see Figure 1).

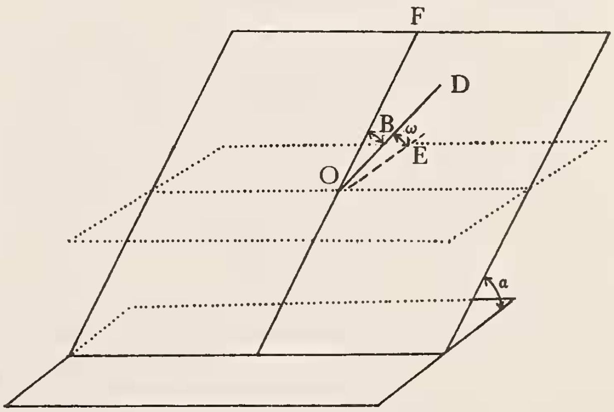

Figure 1: Diagram showing inclined surface and expressions used in finding the degree of accuracy of geotactic orientation: α = angle of inclination of the surface; B = the angular deviation; ω = angle between the snail's true path of orientation and the horizontal. Method of scoring angular deviation: O - D = path of snail; O - E = path of snail projected onto horizontal surface; O - F = line on the surface perpendicular to the horizontal when the surface is inclined 90°.

Pieces of brown paper, 24 inches square, were attached to a piece of cardboard the same size and inclined at angles of 0°, 15°, 30°, 45°, 60°, 75°, and 90° from the horizontal. The paper served as a substrate on which the snails moved.

To track the snail's path of progression, blue ink powder was dusted onto a piece of brown paper which was used as a master sheet. By pressing the master sheet on other sheets of paper, enough ink powder was transferred from the master sheet to these duplicates to show a snail's track easily on the latter. Ten duplicate sheets can be prepared without additional ink powder.

Each snail was placed upon the substrate at its center with no uniformity as to the position of the snail. At this time the snail was withdrawn into its shell, and the surface was in a horizontal position. After the snail had become attached on the substrate, but before it could extend itself, the surface was raised. While performing the preceding steps, a 25-watt red photographic safe-light bulb was used for illumination at a distance of ten feet. The animals were allowed to move for 30 minutes in total darkness. The room temperature (20.0° to 23.7° C.) was recorded at the beginning of each trial. To minimize adaptation, conditioning, or learning that may occur with repeated testing, no snail was allowed to score more than once.

One hundred Helix aspersa were recorded singly at each of the angles of inclination for seven angles. The angular deviations from the vertical on the surface (Figure 1, O-F) for each slope of the surface were scored and their mean calculated. These were plotted against the angle of inclination of the surface. Each angular deviation was scored at a distance of nine inches from the beginning of each run. This distance was obtained by the chance selection of a number from 1 through 12. The standard deviations and the range of each set of angular deviations were also computed.

Geotactic accuracy was determined by solving the following equation: $\alpha - \omega$ = degree of accuracy, where α is the angle of inclination of the surface, and ω is the angle between the snail's true orientation path and the horizontal (see Figure 1). The true orientation path of the snail was determined by solving the following equation: $\sin \omega = \sin \alpha \cos B$, where B is the mean of the angular deviation.

For each angle that the surface was inclined, the degree of accuracy was calculated by using the equations presented above. The degree of accuracy was plotted against the angle of inclination of the plane.

Results

The results of the study are summarized in Table 1, which shows the mean of the angular deviations, the range of the angular deviations, the value of ω, and the degree of accuracy of geotactic orientation for each angle of inclination of the surface.

For all the angles at which the surface was inclined between 15° and 75°, the degree of accuracy remained nearly constant with a value of approximately 2°; however, the degree of accuracy decreased to a value of 8° 53' when the surface was inclined at an angle of 90°. Since in the control situation (0°) there was no vertical component, it was not possible to score angular deviations. In this case the snails moved in an apparently random manner.

Figure 2, in which the means of the angular deviations were plotted against the angle of inclination of the surface (except at 90°), shows that as the angle of inclination of the plane increased, the mean of the angular deviations decreased. The standard deviations and the range of each set of angular deviations at each angle that the surface was inclined are also shown in Figure 2.

Table 1:

Mean and range of the angular deviations, values of ω, and degree of accuracy for each angle of inclination of the surface

Angle of inclination of surface in degrees	Mean of angular deviations	Range of angular deviations	Value of ω	Degree of accuracy
0 (control snails) moved in an apparently random manner				
15	28°21′	1-57	13°10′	1°50′
30	20°56′	1-51	27°50′	2°10′
45	15°38′	1-30	42°55′	2°05′
60	11°45′	1-27	57°59′	2°01′
75	7°41′	1-17	73°08′	1°52′
90	8°53′	0-39	81°07′	8°53′